

Pions in a strong magnetic background *

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We investigate the modification of the pion self-energy at finite temperature due to its interaction with a low-density, isospin-symmetric nuclear medium embedded in a constant magnetic background.

Nuclear matter in strong magnetic fields

The study of nuclear matter under strong magnetic fields has acquired a lot of attention during the last years in the contexts of heavy ion collision physics and lattice QCD [1]. In Ref. [2] we investigate some properties of isospin-symmetric nuclear matter in the limit of low density and temperature, embedded in a strong magnetic background. In particular, we compute the in-medium pion effective mass in the presence of a constant magnetic field to one loop. For this purpose, we consider fully relativistic chiral perturbation theory as a framework for our computation. This is needed to define consistently the fermion propagators in a magnetic background.

Pion self-energy in strong magnetic fields

The leading order interaction Lagrangian, which describe the low-energy phenomenology of nuclear matter, $\mathcal{L}_{\pi N}^{(1)}$, reads [3]

$$\mathcal{L}_{\pi N}^{(1)} = -\bar{\Psi} \left[\frac{g_A}{2f_\pi} \gamma^\mu \gamma_5 \tau \cdot \partial_\mu \pi + \frac{1}{4f_\pi^2} \gamma^\mu \tau \cdot (\pi \times \partial_\mu \pi) \right] \Psi. \quad (1)$$

Here τ is the vector of Pauli matrices in isospin space, π is the isotriplet of pions, f_π the pion decay constant and g_A is the axial-vector coupling.

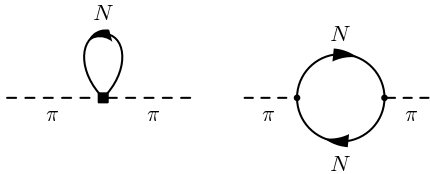


Figure 1: Diagrams contributing to the lowest-order in-medium pion self-energy.

The diagrams contributing to the pion self-energy from the Lagrangian (1) are shown in Fig. 1.

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The effective pion mass is defined as:

$$m_\pi^{*2} = m_\pi^2 - \text{Re } \Pi(m_\pi^{*2}, \mathbf{q} = 0; \mathbf{B}) + (2n+1)|eB|, \quad (2)$$

where $\Pi(q)$ is the pion self-energy, \mathbf{B} is the magnetic field and n is the index of the Landau level. The following results are computed within the lowest-Landau-level (LLL) approximation, which is valid for very intense magnetic fields.

Results

Fig. 2 displays our results for the pion effective mass, \bar{m}_π , as a function of the magnetic field, normalized to the trivial $|eB|$ shift in Eq. (2).

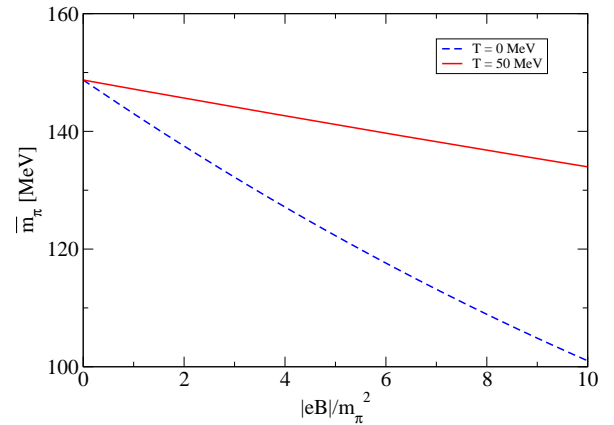


Figure 2: (Color online) Effective pion mass as a function of the magnetic field.

We find that the effective mass of the negatively charged pion drops by $\sim 10\%$ for a magnetic field $|eB| \sim m_\pi^2$, which favors pion condensation at high density and low temperatures.

References

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